10 years of Calf Research at the Southern Research and Outreach Center (SROC)

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Take-Home Message

Complete pre- and post-weaning nutrition and management options for commercial dairy heifer calves have been implemented over the last 10 years at the University of Minnesota SROC. Goals for calf performance in the nursery have been attained by both conventional, moderate intensive or intensive programs. Optimum calf starter intake compliments changes in liquid feeding programs to ensure calves meet their goals. Good quality calves and health management have been important keys to success. Post weaning programs have maintained calf performance which has exceeded initial expectations. The dairy producers who have supported this effort have helped to improve the programs for their heifer calves from 2 to 5 days up to 6 months of age which is a critical phase for growing dairy heifers. Detailed records for each calf that arrives at SROC has helped both the dairy managers and SROC management. The unique partnership between the University of Minnesota, the commercial dairy producers and allied industry collaborators has allowed many options to be considered for calf raising operations.

Introduction

The calf and heifer facilities were upgraded and new facilities were completed in April 2004. The main focus of research has been built upon the original commercial partnership developed with the 3 dairies representing 1,700 dairy cows and allied industry. This allowed for sufficient number of calves to be raised to accommodate applied pre- and post weaning studies developed by the partner team (up to 400 calves/year) and also have calves to be able to conduct studies with other University or allied industry collaborators. Contracts with each of the three dairies are evaluated annually. A close working relationship has developed between the University of Minnesota and management at each of the three dairies which has helped to maintain the quality of heifers raised at SROC. One of the unique aspects of the project is the development of Excel spreadsheets for each dairy tracking every calf that enters and leaves SROC then follow them back to the dairies for first lactation production data. This data set will be used for a comprehensive met analysis in the coming few months to understand the relationship between calf growth and health from 2 to 5 days old up to 6 months on first lactation performance.

Currently, the calf and heifer facility in Waseca contract raises over 1,000 dairy heifer calves annually for the three commercial dairy operations which now represent over 2,000 cows. The overall death loss to date for the 9,500 calves that have arrived at SROC is 2.1%. Calves are picked up twice weekly at 2 to 5 days of age and remain at SROC until 6 months of age. A partnership continues with the three dairies, Hubbard Feeds and Milk Products but with

opportunities for other collaborators from Universities and Industry. This paper will provide a brief management overview of the facility and highlight the results of selected pre-and post weaning applied research programs. The studies will represent those that have been presented as papers at regional and national meetings which include calves assigned to studies up to December 31, 2013.

Calf and Facility Management

Nursery phase. Calves are picked up weekly by SROC staff from the respective dairies on Monday and Thursday and co-mingled n a well-bedded livestock trailer.The respective dairies are continually working to maintain calf quality. At least 3 feedings of colostrum are required before calves are picked-up. A goal is to evaluate the profiles of total serum proteins on all calves upon arrival. In addition, minimizing other potential health issues such as navel infections are a priority for the dairies. During winter months, calf blankets are used at pick-up and remain on the calves at the discretion of SROC staff until they adjust to their new environment. In the nursery phase, calves are housed in one of two 200 ft x 30 ft curtain side-wall naturally ventilated calf barns. Each barn contains two 90 ft x 30 ft rooms with 40 individual pens (approx 30 sqft/calf) within each room. A 20 ft x 30 ft mixing and feed storage area is centrally located in each barn. The rooms are managed as an all-in, all-out system. All pen panels are removed and power washed between calf groups. All bedding material is removed and the remaining front gates and rear panel holders are also power washed. Chopped straw is used for bedding calf pens in the winter and sawdust in the summer months.

Calves will remain in their respective pens for about 56 days unless a specific protocol requires a longer feeding period. Upon arrival, calves are weighed, hip heights taken and two jugular blood samples drawn. One sample is used to check total serum proteins using a refractometer. A comprehensive pre and post weaning vaccination program is administered. Dehorning and tail docking is completed about 30 days after arrival. Calves between 75 and 110 lb at 2 to 5 days of age are assigned to applied nursery studies, if appropriate, across resource location. An individual recording sheet is prepared for every calf regardless if they are on trial or not. Daily records are kept for feed intake (milk and calf starter), fecal scores and health treatments. Period growth parameters are recorded. All data from individual cards are transferred to an Excel worksheet for management and study statistical analyses. An interesting study was recently completed looking at heritability estimates of performance and health traits of Holstein calves. The data set of SROC dairy calves evaluated 6,189 observations for analyses. Performance traits were moderately heritable, with estimates ranging from 0.25 to 0.37. Health traits had low heritabilities, ranging from 0.01 to 0.11. Results suggest that calf performance and health can be improved genetically.

The addition of an automatic calf feeding system in a renovated calf room. An Urban automatic calf feeding system at SROC has been functional since September 2011 in a renovated calf room. The automatic feeder calf room (AFR) is the 5th room to be used in a rotation with 4 rooms of 40 calves housed in individual pens for an all-in all-out system. Calves will be placed into the AFR upon arrival to SROC. The Urban feeder is capable of feeding the same or two different milk replacers independently to calves co-mingled in two pens of 23 (32 sq ft/calf). Initially, within each pen automatic grain feeders or bunks were evaluated for calf starter intake. Calves have used the bunk feeder more readily for establishing good feed intake. The initial goal was to use a base conventional program similar to that fed in individual pens so comparisons can be assessed. Calves are fed 3-4 times a day. Calves using the automatic feeder on a conventional program tend to have lower overall gains than those fed in individual pens. Much of this is due to the adjustment to feeding amounts especially during the first 2 weeks. Health costs were higher for calves on the AFM vs. IPF calves. Proper ventilation is very

critical to the success of an AFM system. Recent calf groups have been fed more moderate intensive or intensive feeding programs. With good starter intake it is not necessary to feed over 2 lb of milk replacer powder/day to double birth weight in 56 days. In fact the last group of calves on the AFM fed a conventional program doubled birth weight, weaning at 42 days. Group feeding can be very successful if you can keep calves healthy and get them to eat starter early.

Post weaning group housing. Two post weaning barns are used to house heifers until they attain 6 months of age. A new 65 ft x 150 ft curtain side-wall naturally ventilated facility completed in 2004 is located north of the calf nursery barns. This contains 20 12ft x 25 ft pens and a scale with handling area. The front part of each pen is a scrape alley and the rear a manure pack. Heifers are fed through diagonal bars from a central feed alley. The front alley is scraped weekly and the manure pack cleaned out as often as deemed necessary. Pens are re-bedded once or twice weekly. A second post weaning barn is an existing 80 ft x 160 ft manure pack pole barn. The barn contains 20 15 ft x 30 ft pens each with 10ft concrete feed bunks. There is a central scale and heifer handling area. This barn is cleaned out twice annually but pens are re-bedded once or twice weekly. Both barns are used for studies alternating a complete study between each. Heifers are fed once daily and both barns are managed as a continuous flow system.

Calf profiles. Table 1 provides a heifer calf profile including average total serum proteins and a summary of growth parameters at 6 months of age.

Table 1. Profile of heifer calves assigned to nursery studies from 3 dairy farms from 2-5 days up to 6 months of age through 2013.

Item	Farm A	Farm B	Farm C
Number of heifers assigned to studies	1,156	1,805	1,797
Initial BW, lb	88.3	88.0	86.0
Initial serum protein, g/dl	5.6	5.5	5.4
Final BW, lb	474	448	452
Final hip height, in	45.6	45.1	45.0
ADG, lb	1.91	1.88	1.89

In studies to date there do not appear to be differences in calf gain across serum protein profiles. Given good management conditions with acceptable death loss for co-mingled calves from 3 dairies, calf performance can be maintained even with a variable range of serum proteins. There is an indication that improving serum protein concentrations decreases the performance variance.

Calf nursery research studies. A target goal for calf performance in the nursery phase is to double the initial body weight by the end of the nursery phase and gain at least 4 inches of frame height in the same time period. It has been suggested that during the first 2 weeks in the nursery a goal is to attain 1 lb/day daily gain to aid in calf health. These goals have been attained in a number of calf groups but there are some variations by season of the year.
A standard feeding protocol is to offer a 20:20 all milk protein medicated milk replacer (MR) at 0.625 lb/feeding twice daily diluted with water to 12.5% solids for 35 days and once daily from day 36 to weaning at 42 days. Total solids in the MR can vary from 12.5% up to 16.7% depending on the program being evaluated. An 18% CP complete texturized calf starter (CS; including a coccidiostat) is offered from day 1. Fresh water is offered daily. This standard feeding protocol has been included in as many nursery studies as possible to build a control data base. Prior to February 2010, MR were medicated with 2:1 neomycin (400g/ton):oxytetracycline (200 g/ton; unless noted otherwise). Since 2010, calves have been

fed a non-medicated MR supplemented with 1:1 higher concentration of neomycin:oxytetracycline (1600g/ton) for the first 14 days. In the winter months the volume of MR may be increased based on the ambient temperature taken in the morning. This adjustment only occurs from 0° F and below. Calves will remain in their respective pens until 2 weeks after weaning and then transfer to group pens of 6-8 heifers. Occasionally calves have remained in the nursery for up to 70 days. At least 20-25 calves are assigned for each treatment group for nursery studies.

Liquid feeding programs. The initial MR study in 2004 compared conventional vs. modified intensive or intensive feeding (Table 2). Growth advantages were observed when calves were fed the modified intensive or intensive high solids MR but not the low solids modified intensive MR compared to the conventional programs. Calf starter intake was the lowest but gain/feed was the highest for the intensively calves. The calves remained in their pre-weaning treatments and were moved to group pens where they were limit-fed a 16 (conventional) vs 18% CP grain mix (modified intensive and intensive) with access to long hay. There were no differences in post weaning performance from 9 to 25 weeks of age. The DHIA records for each herd were used to monitor the first lactation performance of the calves on the study. First calving age was reduced for intensive (23.5 mth) but not modified intensive (24 mth) vs 20:20 control (24.4 mth). There were no significant milk production differences for 305 Std ME. A complete cost:benefit analyses will determine the viability of each of these MR programs. This study was a base to use for further research.

Feeding strategies for MR programs. Calves have been offered different MR at varying feeding rates since the first 2004 study. Highlights from selected studies are described. An enhanced feeding rate using a 20:20 MR (fed at 15% solids) as indicated in Table 3 was conducted from October 2009 to January, 2010. There were some advantages for increasing milk replacer rate from 1.25 to 1.50 lb/day for the first 14 days on the study but not during the overall pre-weaning period. Calf starter intake reflected the differences in energy from the milk replacer strategies. There were frame size benefits for maintaining a higher milk replacer feeding rate. Economic assessment should be made to identify the feeding strategies in the nursery phase. Calves did not meet growth goals over the 56 day study.

Feeding a standard MR and CS program were compared to 20:20 fed at 1.5 lb/day for 14 days and 1 lb/day from day 15 to 35 days vs. 24:18 fed at 1.5 lb/day for 14 days and a 20:20 at 1 lb/day from day 15 to 35 or a 28:16 MR fed at 1.5 lb/day for 14 days and 20:20 at 1 lb/day from day 15 to 35. Calves were fed ½ the amount of MR once daily from day 36 to weaning at 42 days. Strategies for initiating a moderately-accelerated milk replacer program (higher protein milk replacer and moderate feeding rate) for the first 2 weeks of life followed by a reduction in milk replacer feeding rate from d 14 to weaning did not improve pre-weaning performance and health compared with a conventionally-raised control group. Moderately-accelerated milk replacer programs did attain or were close to attaining a bench mark goal of 1 lb of daily gain for the first 14 days but this advantage was not sustained when the milk replacer feeding rate was reduced although there were indications of higher calf starter intake.

These studies were used to design further MR programs from 2012 to 2013. The first in a series included a 20: 20 MR fed at 1.25 lb/day from d 1-35 and 0.625 lb/day from day 36-42; 20:20 MR fed at 1.50 lb/day from day 1-35 and 0.75 lb/day; 24: 20 MR fed at 1.25 lb/day from d 1-35 and 0.625 lb/day from day 36-42; 24:20 MR fed at 1.50 lb/day from day 1-35 and 0.75 lb/day; The results demonstrated that calves fed a conventional MR at different feeding rates with different CP concentrations performed similarly. Calves fed higher CP MR at higher feeding rates had numerically greatest daily gain. A moderate MR feeding program using the 24:20 MR

at different feeding rates during a 56-d nursery study was the next study in the series. An 18% CP texturized calf starter (CS) offered free choice through d 56. Calves were offered a 24:20 MR fed at 0.625 lb x2 daily for 35 d; a 24:20 MR fed at 0.75 lb x2 daily for 35 d; 24:20 MR fed at 0.75 lb x2 daily for d 1 to 7 and 0.95 lb x2 daily from d 8 to 35 and a 24:20 MR fed at 0.75 lb x2 daily for d 1 to 7 and 1.09 lb x2 daily from d 8 to 35. All calves fed their respective MR x1 daily from d 36 to weaning at 42 d. Feeding calves a 24:20 MR at 1.25 and 1.50 lb daily maintains CS intake to enhance protein and energy intake by calves. Feeding > 1.50 lb daily inhibits CS intake without improving growth rates. The previous studies have demonstrated that a 24:20 MR modified accelerated fed at higher feeding rates resulted in improved growth performance and feed efficiency but not linearly.

Table 2. Performance of heifer calves fed varying milk replacer and complete texturized starter programs (least squares means).[a]

	Milk Replacer (%CP, %Fat)				
Parameter	**20:20 C Non-Acidified**	**20:20 C Acidified**	**28:16 MIHS**	**28:16 MILS**	**28:16 I**
Feed rate lb/day MR[1]	1.25	1.25	1.5	1.5	2.25
Solids %	13.88%	13.88%	16.67%	12.50%	16.67%
CS CP %, as-fed	18%	18%	22%	22%	22%
No. calves	26	28	26	29	24
Init. BW, lb	90.9	91.08	89.74	87.05	88.86
Init. HH, in	31.80	32.00	31.78	31.73	31.81
SP, g/dl	5.00	5.11	4.90	4.89	4.98
Pre-weaning					
CS DM 42 d, lb	43.38^{b}	41.62^{b}	43.49^{b}	37.99^{b}	23.61^{c}
CS DM 49 d, lb	73.50^{b}	70.64^{b}	74.82^{b}	67.98^{b}	43.85^{c}
Milk DM, lb	47.76^{b}	47.45^{b}	57.51^{c}	55.40^{c}	94.89^{d}
ADG 1-42 d, lb	1.25^{b}	1.19^{b}	1.47^{c}	1.39^{c}	1.74^{d}
ADG 1-49 d, lb	1.34^{bc}	1.28^{b}	1.52^{d}	1.45^{cd}	1.78^{e}
Overall 56 days					
Final BW, lb	171.45^{b}	167.55^{b}	180.09^{c}	169.42^{b}	188.61^{d}
CS DM 56 d, lb	108.81^{b}	105.09^{b}	111.87^{b}	102.63^{b}	77.70^{c}
Total DM, lb	156.57^{b}	152.55^{b}	169.38^{cd}	158.03^{bc}	172.59^{d}
ADG, lb	1.43^{b}	1.36^{b}	1.61^{c}	1.47^{b}	1.78^{d}
Total gain, lb	80.54^{b}	76.47^{b}	90.35^{c}	82.37^{b}	99.75^{c}
Gain/feed, lb	0.51^{b}	0.50^{b}	0.53^{b}	0.52^{b}	0.58^{c}
Final HH, in	35.87^{b}	35.83^{b}	35.91^{b}	35.71^{b}	36.65^{c}
HH gain, in	4.07	3.83	4.13	3.98	4.84
Total BW gain, %	189	184	201	195	212

[a]Adapted from Ziegler et al. (2005b) and Raeth-Knight et al. (2009).

[b,c,d]Means in the same row with different superscripts differ ($P < 0.05$).

[1]All C, MIHS and MILS calves fed the MR in 2 equal feedings twice daily for 35 days and ½ the amount x1 daily from day 36-42. Intensive calves were fed MR in 2 equal feedings twice daily for 42 days and ½ the amount x1 daily from day 43-49.

Table 3. Feeding rates for an enhanced conventional program.				
Milk Replacers	**Control 20-20 AM**	**20-20 AM – 21 days**	**20-20 AM – 28 days**	**20-20 AM – 35 days**
Days 1-21 MR Feed Rate lb/day	1.25	1.50	1.50	1.50
Days 22-28 MR Feed Rate lb/day	1.25	1.00	1.50	1.50
Days 29-35 MR Feed Rate lb/day	1.25	1.00	1.00	1.50
Days 36-42 MR Feed Rate lb/day	0.625	0.50	0.50	0.75

The design of the third study in the series was conducted in the summer months to evaluate performance and health of calves fed a varying levels of protein and fat at different feeding rates in the MR to determine if lowering the fat level or increasing the protein level affects calf performance through 8 weeks of age during the summer months. A 24% protein:20% fat non-medicated all-milk protein milk replacer at 1.25 lb powder daily (reconstituted with water to 14.7% solids) for 35 days and 0.625 lb/ once daily from day 36 to weaning at day 42; compared to 24:20 MR at 1.50 lb daily for 35 days and 0.75 lb once daily from day 36 to 42; a 24:16 MR fed as in treatment 2; vs. 24:16 MR fed as in treatment 3 for 7 days and 1.875 lb from day 8 to 35 and 0.9375 lb once daily from day 36 to 42; and a 26:16 MR fed as in treatment 4. All milk replacers were balanced for essential amino acids. Calves were offered free choice 18% CP texturized calf starter and water daily. Table 4 summarizes the main effects. This study demonstrates that feeding a modified accelerated MR (24:20) at a moderate feeding rate improves ADG compared to calves fed MR having similar or different CP and fat combinations. Frame growth was excellent for all calf groups.

Alternative protein sources for MR. The cost of milk proteins have remained high for some time and alternative proteins that do not compromise calf performance but result in lowering MR costs are worth pursuing. This has been addressed in a number of studies from which selected examples are outlined. In the Fall of 2005 the first study used the standard SROC nursery feeding program (MR and calf starter) compared to calves fed MR replacing 50% of the milk protein with hydrolyzed wheat gluten (WG) protein vs. 50% of the milk protein with soybean protein concentrate (SPC) vs. replacing 30% of the milk protein with WG vs. 50% of the milk protein with 25% WG and 25% SPC. The MR were balanced for amino acids. Calves fed an all milk protein 20:20 MR had better overall performance than calves fed MR containing alternative protein sources. However, calf performance for those fed the standard SROC program exceeded that of the control calves from other SROC studies. Calves fed the alternative protein MR gained as well as control MR calves in other SROC studies. Intake of calf starter contributed to the calf performances.

Partially replacing milk protein in a 20:20 milk replacer with 4 or 8% spray dried animal plasma resulted in similar calf performance and health during a late fall/winter study to those fed an all-milk protein milk replacer. There were no differences in total amino acids across milk replacers used. A winter study compared the control MR vs. replacing 33% of milk protein with hydrolyzed wheat protein isolate with Lys and Met to equal total sulfur amino acids (AA) vs. 33% peptide powder formulated for AA as in treatments 1 and 2 or 33% peptide powder formulated for AA as the other treatments plus additional Trp and Thr equivalent to treatment 1. Day 1 to 14, 1:1 neomycin: oxytetracycline was added to the MR solution. Partially replacing milk protein in MR with either hydrolyzed wheat protein isolate or peptide powder balanced for selected AA

resulted in acceptable calf performances and health. A follow-up study using similar alternative protein sources is currently underway.

Table 4. Daily gain, frame growth, intake of milk replacer (MR), calf starter (CS) gain/feed and water.[1]

Item	24:20 1.25 lb	24:20 1.5 lb	24:16 1.5 lb	24:16 1.875 lb	26:16 1.875 lb	SEM
No. calves	25	25	25	25	26	
ADG, lb/d						
1 to 14 d	0.97^{c}	1.19^{bc}	1.05^{c}	1.31^{ab}	1.43^{a}	0.06
1 to 42 d	1.36^{ab}	1.47^{a}	1.34^{b}	1.41^{ab}	1.45^{a}	0.05
1 to 56 d	1.57^{ab}	1.66^{a}	1.54^{b}	1.56^{ab}	1.58^{ab}	0.06
HH gain, in						
1 to 56 d	4.68^{ab}	4.92^{ab}	4.56^{b}	5.02^{a}	5.05^{a}	0.21
Total MR intake, kg/d						
1 to 42 d	1.13^{a}	1.39^{b}	1.38^{b}	1.63^{c}	1.62^{c}	0.02
Total CS intake, lb/d						
1 to 42 d	1.04^{a}	0.86^{b}	0.82^{bc}	0.64^{cd}	0.60^{d}	0.12
1 to 56 d	2.05^{a}	1.92^{a}	1.83^{ab}	1.65^{bc}	1.59^{c}	0.09
Gain per feed						
1 to 42 d	0.63^{bc}	0.65^{ab}	0.61^{c}	0.63^{ab}	0.66^{a}	0.01
43 to 56 d	0.44	0.44	0.44	0.44	0.43	0.01
1 to 56 d	0.42^{a}	0.42^{a}	0.39^{b}	0.39^{b}	0.39^{b}	0.01
Water intake, L/d						
1 to 7 d	0.96^{w}	1.29^{vw}	1.46^{v}	1.30^{vw}	1.34^{vw}	0.27
8 to 14 d	1.05^{a}	1.28^{b}	1.34^{b}	1.35^{b}	1.43^{b}	0.16
15 to 21 d	1.43	1.58	1.56	1.52	1.62	0.22
22 to 28 d	1.76	1.85	1.63	1.65	1.68	0.23
29 to 35 d	2.44^{vw}	2.57^{w}	2.40^{vw}	2.32^{vw}	2.16^{v}	0.22
36 to 42 d	4.33^{ab}	4.58^{a}	4.03^{ab}	3.19^{c}	3.72^{bc}	0.28
43 to 49 d	7.27^{ab}	7.58^{a}	6.76^{ab}	6.41^{b}	6.59^{b}	0.31
50 to 56 d	8.40^{ab}	8.78^{a}	7.67^{bc}	7.59^{bc}	7.57^{c}	0.32

[1]Adapted from Strayer (2014).

$^{a, b, c, d}$Means differ, $P \leq 0.05$.

$^{v, w}$Means differ $P \leq 0.10$.

In a recent study calves were fed an all-milk (AM) protein non-medicated 20:20 MR vs. 50% of total protein from wheat and plasma or 50% of total protein from soybean protein concentrate (SPC) and plasma (SPL) vs. 50% combination of wheat, SPC and plasma. Day 1 to 14, 1:1 neomycin:oxytetracycline was added to the MR solution. Across treatments, calves doubled their initial BW and gained > 4 inches in frame growth. There were indications that including plasma in the MR reduced scouring days. There were no differences in health treatment costs. Replacing 50% of the total milk protein in MR with alternative sources resulted in calf performance and health similar to all milk protein. A similar study but using a moderate MR program (24:20) is currently being conducted.

Energy sources for MR. Animal fats (lard) are commonly used for MR formulations as energy sources. Interest in alternative energy sources has focused on all-vegetable fat sources or a combination of animal and vegetable fat. A study was undertaken in the winter of 2006 to look at calf performance when offered varying energy sources using a 24:20 all milk protein medicated MR fed as per standard SROC protocol with a 18% CP CS. Fat treatments were: Animal fat (AF); Vegetable blend of 80% palm oil and 20% coconut oil (VF); and, AF plus a blend of medium chain tri-glycerides containing 1% caproic, 69% caprylic, 1% capric and 29% lauric acids fed at 5 g/calf daily (AFVF). Calves fed AF tended to have higher CS and total DMI than those fed AFVF but overall calf performance was not influenced by fat source.

Nutritional supplements and additives for MR and CS programs. Programs using nutritional supplements have been based on the SROC standard MR and CS program. These have included mannan oligosaccharides (2 g/calf daily), fructo-oligosaccharides (inulin, fed at 5.67 g/calf daily) and a combination in a non-medicated 20:20 MR. The additives did not affect pre- and immediate post-weaning calf performance vs. non-medicated control MR. Other supplements that have not affected calf performance included 0.75% organic acids in the MR and 0.2% in the CS (fumaric, orthophosphoric, and citric acids), yeast in MR (5%) and CS (2.5%). Using essential oils for a non-medicated MR (1.8 g/lb) and CS (0.9 g/lb) without additives resulted in similar calf performances compared to a medicated MR and CS with rumensin.

Heat abatement in the summer months. Typically calf performance during the summer months is not as good as during other times of the year. Two studies were conducted in the summer of 2012 and 2013 to evaluate pre- (and post-weaning calf performance and health when fed a 20:20 MR with supplements to aid in heat abatement. In study 1, Calves were assigned to MR supplements, none; B-complex vitamin premix fed at 1.42 g/calf daily and betaine fed at 5 g/calf daily. There was trend for an increase in CS intake by calves fed either supplement but no growth or health differences. In study 2 supplements included B complex vitamin premix fed as in study 1 or B-complex vitamins as in 2 plus an electrolyte mix fed at 28 g/calf daily. Again no performance or health differences. Sodium butyrate was included \in the MR (0.3% and CS (0.33%) There were benefits to calf performance of adding sodium butyrate to non-medicated milk replacer during the summer months. Using sodium butyrate in calf starter appeared to be an acceptable alternative to rumensin. More research is needed to fully understand how best to improve nursery calf performance in the summer months.

Calf starter programs. Offering a high quality CS and promoting optimal intake is integral to the success of all SROC nursery feeding programs. Good CS intake could allow for earlier weaning and reduce extra costs of extending the liquid feeding period.

Calf starter composition and physical form. In the initial SROC CS study, calves were fed the standard SROC MR program with texturized CS containing 6, 9 or 12% liquid molasses. Overall, when compared to calves fed 6% molasses, those fed the 12% molasses had 8.3% lower gains and utilized their feed 5.3 % less efficiently. Calves fed the 9% molasses had similar performances to those fed the 6% level. A common question is why do we not feed complete pellets vs texturized CS for consistency of product? This was investigated when calves were offered free choice 18% CP CS as a complete texturized (T), complete pellet (P) or P with chocolate, whey or sweet tart as intake enhancing supplements. Calves fed the complete T CS had the highest feed efficiency and gained 7.1% faster than calves fed the complete P. The pelleted CS had lower energy levels than the texturized CS accounting for differences. Intake enhancing supplements were not advantageous.

Studies have found that replacing steam flaked corn with whole corn, air or flame roasted corn in completer calf starters resulted in as good if not better calf performance during a 56 day nursery period. There were indications of starter differences in calf health parameters and treatment costs. Calf starter have allowed for an improved 18% CP CS with digestible fiber levels that enhanced DMI.

Ionophores and other coccidiostats. Research has focused on using the standard nursery SROC program. An overview of examples is discussed. The ideal monensin level in CS seems to be variable. Calf starters with or without monensin (73, 109, and 145 mg/lb) were formulated. Calf performance was similar but CS intake declined with increasing monensin level. Calves were transitioned to group pens and fed a common diet. Calves were transitioned to grower pens (7 heifers/pen) and performance was monitored from 9 to 25 wk of age. Calves were each limit-fed a common 16% CP grain mix containing monensin (94 mg/lb d1-84, and 156 mg/lb d 85-112) fed at 6 lb/day for 56 d then 5 lb/day for an additional 56 d with free choice hay. .Calves fed increasing levels of monensin in the nursery tended to show performance compensation when fed a common diet in group pens. Decoquinate (22.5 mg/lb), monensin (20 mg/lb), lasalocid (44 mg/lb) and bambermycin (22 mg/lb; extra label for confined calves) in CS were compared to no additives from August to November, 2013 Calf performance was acceptable for all calf groups but particularly excelled when calves were fed starters with decoquinate, lasalocid and bambermycin.

Using glycerin as an energy source for calf starters and grain mixes in group pens post weaning. Calves were fed a standard MR and CS program. The18% CP texturized CS was ground and pelleted .The control pellet was compared to pellets where glycerin replaced 3 and 6% of the corn.There were no performance differences in the nursery. Calves fed the 6% glycerin pellet had highest treatment costs. Calves were transitioned to group pens and fed the control CS for 7 days then offered p3 grower diets among 5 replicated pens. Glycerin replaced 3 or 6% of the corn in a pelleted grain mix fed at 6 lb/day with free choice hay for 84 days and a common whole corn and pellet grain mix from day 85 to 112. Heifers 6% glycerin had improved gains vs. those fed 3% glycerin or the control pelleted grain mix. Feed efficiencies were also improved in heifers fed both glycerin diets.

Post weaning transition and group housing programs. Transitional nutrition and management of calves when moving from individual to group housing is a challenge on many dairy operations. Contrary to expectations, grouping calves in the nursery prior to moving the grower pens was not advantageous. On-going SROC research is looking at ways of improving this adjustment period by management strategies in the nursery prior to moving or changes in feed formulations during the transition. Once adjusted to the group pens, post weaning studies have been implemented. An initial study in 2004 found that continually feeding a grain mix at 6 lb/heifer daily with access to long hay for 112 days resulted in good growth but higher than expected body condition. Follow-up studies then included variable grain feeding rates. A summary of heifer performance on the SROC control limit-fed whole corn (WC) and pellet (P) 16% grain mix program across 4 studies is summarized in Table 5 which was the basis for improving post weaning nutrition management. Key points to note are average hay intake, average DM intake as a % of body weight and heifer performance parameters. Other studies have looked at protein sources (dried distillers grains and urea), grain mix protein levels (13,16,19% CP), rumen fermentation enhancer , fiber levels, and limit vs full feeding grain mixes for example. Regardless of feeding regimen whether limit for full- feeding grain mixes. Feeding a TMR of ensiled hay, distillers grains and sweet corn cannery waste resulted in a lower cost alternative feed for 3 to 6 mth old heifers. Expected ADG by heifers from 9 to 25 wk of age has been 2 to 2.2 lb/day with DMI of 3% of BW.

Table 5. Examples of post weaning heifer performance from 9 to 25 weeks of age from when limit fed a 16% CP whole (WC) corn and pellet (P) grain mix with access to hay, 2004 to 2007.

Parameter	A	B	C	D
Mth study started	July 2004	December 2005	January, 2007	July, 2007
WCP, lb as-fed/d	112 d 6 lb	56 d 6 lb 56 d 5 lb	28 d 6 lb 84 d 5 lb	28 d 6 lb 84 d 5 lb
No. pens of 6 heifers	4	4	5	4
Init. BW, lb	187.7	208.0	194.3	187.8
Init. hip height, in	36.98	36.9	36.8	36.7
Init. BCS	2.97	2.96	3.03	2.90
Period 1-112 d				
BW 112 d, lb	462.0	464.6	459.7	423.8
Daily gain, lb	2.45	2.29	2.37	2.11
WCP/d, lb DM	5.4	4.85	4.75	4.7
Hay/d, lb DM	3.9	5.27	4.83	4.6
Feed/gain, lb	3.80	4.42	4.04	4.41
DMI, % of BW	2.86	3.00	3.30	3.10
Final HH, in	45.12	45.01	45.0	44.4
HH gain, in	8.14	8.11	8.2	7.7
BW gain:hght ratio	33.7	31.6	32.4	30.7
Final BCS	3.96	3.73	3.88	3.80
BCS gain	0.99	0.77	0.85	0.90

Forage quality. The variability of hay quality offered to heifers is often related to market prices and current inventory on the farm. A SROC study investigated feeding hay of low (100 RFV) with or without a low moisture molasses block (30% CP); medium (134 RFV) or high (154 RFV) quality hay fed with a 16% CP cracked corn and pellet grain mix for 112 days (6 lb/day for days 1-14 and 4 lb/day from days 15-112).Using a low moisture block supplement (B) with 100 RFV hay increased daily gain by 4% and feed efficiency by 3.3% compared to feeding 100 RFV without a block supplement. Average daily block consumption was 0.3 lb/heifer. Using a 130 RFV hay compared to 100 RFV hay increased daily gain by 9% and feed efficiency by 4%. Using a 154 RFV hay compared to a 130 RFV hay increased daily gain by 1.4% and feed efficiency by 5.7% over the 112 day study. Heifer performances were acceptable and an economic comparison should be the criteria to select the hay of choice when limit feeding concentrates.

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Notes